5.1 Geology and Soils

Geology and soils are resources with defining characteristics (such as soil structure, composition, or geologic formations) that are unique or valuable or support unique habitats. Geology and soils can also influence the potential for geologic hazards, such as landslides, earthquakes, seismic effects (e.g., surface fault ruptures, strong ground shaking, liquefaction, lifting and lowering of the surface, and tsunamis), and volcanic activity. Understanding the types of soils and the underlying geologic conditions is important in determining whether a project would be exposed to increased risks related to these conditions.

This section describes the geology and soils in the study areas. It then describes potential impacts on geology and soils resulting from construction and operation of the proposed export terminal, as well as the geologic conditions in the study areas posing a risk to the project areas.

5.1.1 Regulatory Setting

Laws and regulations relevant to geology and soils are summarized in Table 5.1-1.

Table 5.1-1. Regulations, Statutes, and Guidelines for Geology and Soils

Regulation, Statute, Guideline	Description
Federal	
Clean Water Act Section 402 General Permit for Stormwater Discharges Associated with Construction Activities	Primarily deals with water quality but includes eroded soils potentially delivered offsite via runoff. Mandates certain types of construction activities (and operations) comply with the EPA NPDES program. The EPA has designated Washington State Department of Ecology the nonfederal authority for the NPDES program in Washington State. Includes development of a stormwater pollution prevention plan.
Local	
Cowlitz County Critical Areas Protection Ordinance (CCC 19.15)	Designates geologically hazardous areas (including seismic, volcanic, erosion, and landslide hazards) and defines performance standards and specific requirements for development within these areas.
Cowlitz County Grading (CCC 16.35)	Grading plan requirement and standards including the protection of water quality from adverse impacts of erosion and sedimentation.
Cowlitz County Building Code (CCC 16.05)	Cowlitz County has adopted the 2012 International Building and Residential Codes.
City of Longview Comprehensive Plan (Off-Site Alternative only)	Chapter 5, Natural Environment Element, including Goals, Objectives, and Policy for Geological Hazards
City of Longview Critical Areas Ordinance (LMC 17.10.140) (Off-Site Alternative only)	Classifies geologic hazard areas (seismic, landslides, erosion, mines, volcanic) and contains procedures to address them.

Notes:
EPA = U.S. Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; CCC = Cowlitz County Code; LMC = Longview Municipal Code

5.1.2 Study Area

The direct impacts study area for geology and soils includes the project areas for the On-Site Alternative and Off-Site Alternative (Figure 5.1-1). The indirect impacts study area includes the broader geologic environment that can influence the project areas. These broader geologic influences include earthquakes (seismicity) and their associated impacts (e.g., ground shaking) as well as tsunamis (large earthquake-generated waves that can affect coastal zones and may extend some distance up large rivers) or off-site landslides that might reach the sites. These study areas are based on the Corps' *NEPA Scope of Analysis Memorandum for Record* (MFR) (2014) then adjusted to reflect groundwater characteristics in and near the project areas.

5.1.3 Methods

This section describes the sources of information and methods used to evaluate the potential impacts associated with the construction and operation of the proposed export terminal.

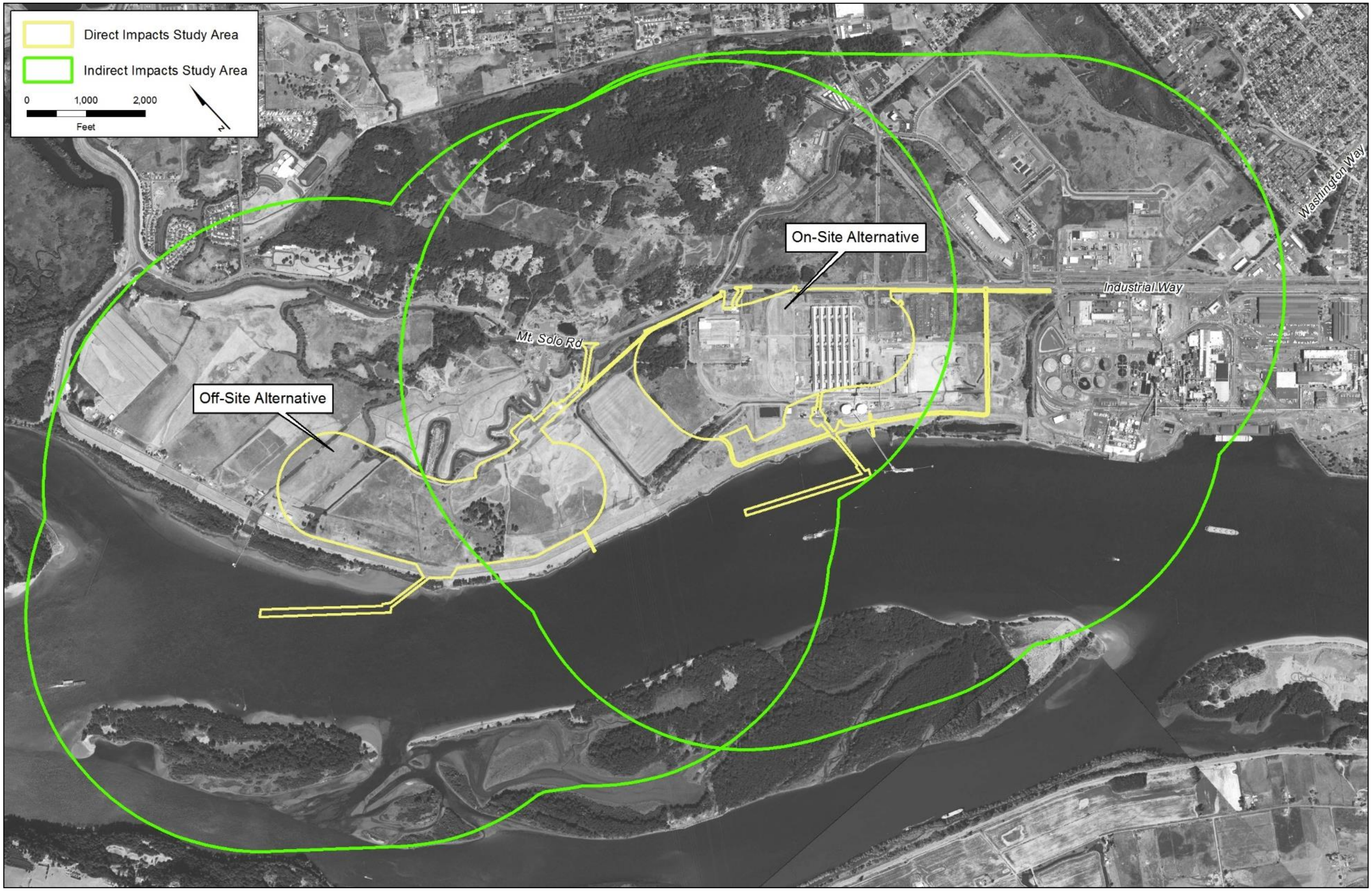
5.1.3.1 Information Sources

Information with respect to geology and soils was collected through review of information and reports provided by the Applicant as well as other sources of information and scientific literature, including Washington Department of Natural Resources Division of Geology and Earth Resources materials, U.S. Geological Survey (USGS) maps and reports, U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) soil information, and geological and soil literature. Additionally, a site visit by a professional geologist conducted on January 29, 2014, provided an overview of affected environment at the project area.

The following sources of information were used to identify the potential impacts of the On-Site Alternative, Off-Site Alternative, and No-Action Alternative on geology and soils in the study area.

- USGS National Seismic Hazard Maps and associated report (U.S. Geological Survey 2013).
- Cascadia Region Earthquake Workgroup (2013) report on the Cascadia Subduction Zone earthquakes.
- Washington Department of Natural Resources Division of Geology and Earth Resources geologic mapping and geologic hazards of the Longview area (various).
- NRCS soil mapping (2013).
- Geotechnical engineering reports and geotechnical engineering data reports prepared for the project area (GRI 2011, 2012).
- Professional workshop and refereed scientific journal materials on tsunamis in the Columbia River.
- Geology and soil report prepared for the project area by the Applicant (URS Corporation 2013).

Figure 5.1-1. Geology and Soils Study Areas



5.1.3.2 Impact Analysis

The analysis of potential impacts related to geology and soils considered the following.

- Regional and project area characteristics (bedrock, unconsolidated sediment, and soil characteristics) and how they could influence site or structure stability through soil erosion, landslides, and settling.
- Potential ground shaking and ground settling due to earthquakes and the stability of the underlying materials.
- The potential for impacts related to volcanic hazards and tsunamis.

5.1.4 Affected Environment

This section describes the affected environment in the study areas for the On-Site Alternative and Off-Site Alternative related to geology and soils affected by the construction and operation of each alternative. Broader geologic context is provided as a foundation for the project area-specific analysis presented in the following section.

5.1.4.1 On-Site Alternative

Geology in the Project Area and Vicinity

The project area is located on the north shore of the Columbia River, approximately 5 miles downstream of the confluence of the Cowlitz and Columbia Rivers (at approximately river mile 63 in the Columbia River). Levees were constructed along the river side of the project area (Figure 5.1-2) around 1920, and the area has been used as an industrial site since the 1940s (Anchor QEA 2011).

The project area is relatively level with some steep slopes descending into drainage ditches on the northern part of the project area and to the Columbia River on the south side. Soils consist mostly of alluvium (i.e., river deposits of gravel, sand, and silt) as well as human-made sources of fill. The project area is at an elevation approximately 16 feet above sea level.

The adjacent Columbia River navigation channel is approximately 43 feet deep at low tide (National Oceanic and Atmospheric Administration Chart 18524) and from 28 to 42 feet deep at low tide at the location of the proposed docks (Docks 2 and 3). No unique geologic physical features, such as unique geologic formations, rock outcroppings, cliffs, or soil formations, occur at the project area.

The study areas exhibit attributes typical of the lower Columbia River valley. The regional geology is dominated by events related to the eastward movement of the Juan de Fuca tectonic plate against the North American plate (Evarts et al. 2009; Parsons et al. 2005). As these plates shift, the Juan de Fuca plate descends below the North American plate and it liquefies at depth. The associated magma (lava) rises to the surface to form the volcanic Cascade mountain range.

Areas of exposed bedrock are present near the project area. These areas include Mount Solo to the immediate north of the On-Site Alternative and Off-Site Alternative project areas and Mount Coffin approximately 0.5 mile upstream of the project area (Washington Department of Natural Resources 2014). The outermost bedrock on Mount Solo is mapped as volcanic rocks (basalt). Within and adjacent to the indirect impacts study area, landslides are also mapped along the slopes of Mount Solo (Figure 5.1-3).

Figure 5.1-2. Levees in the Project Area and Vicinity

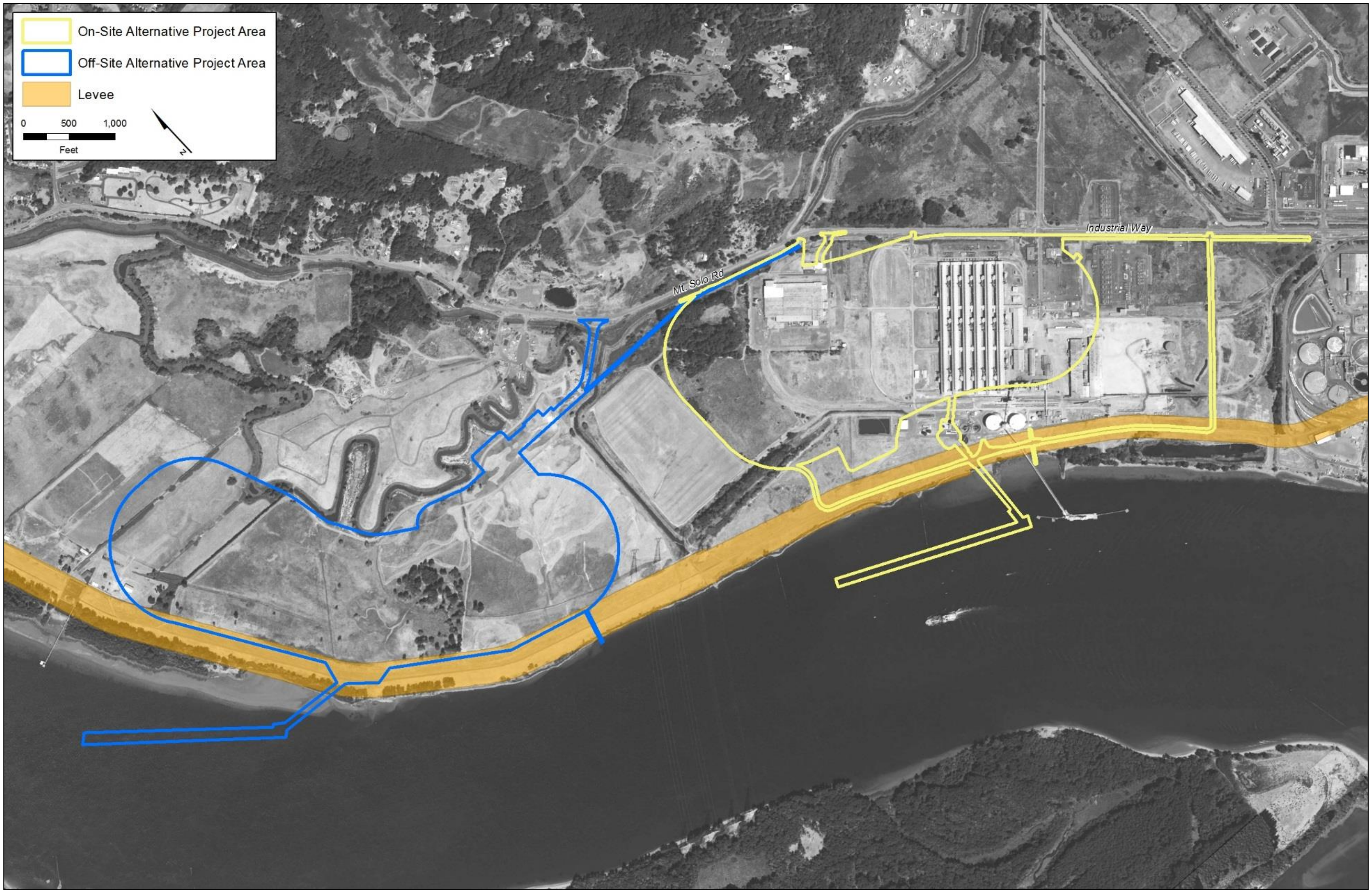
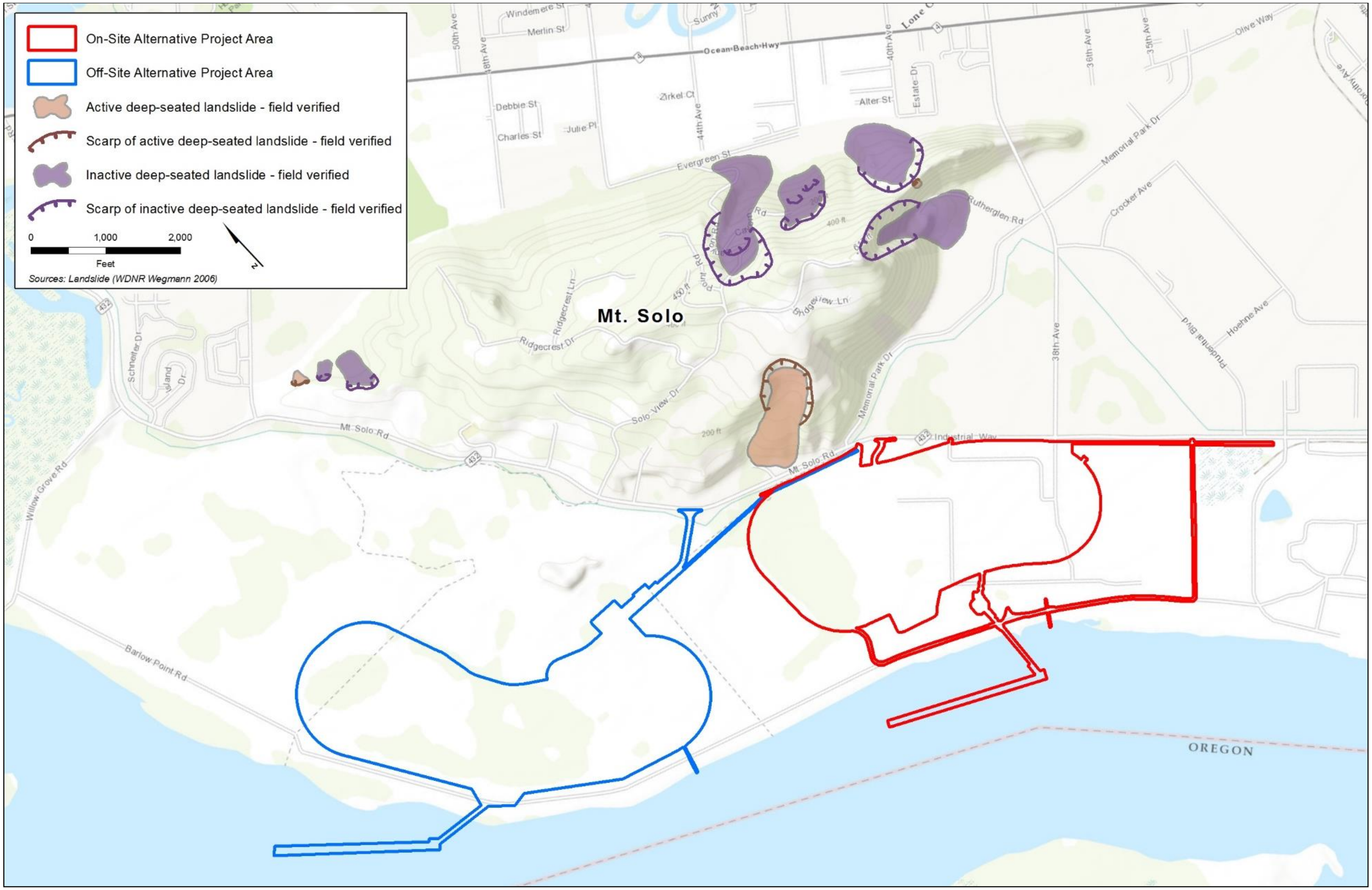


Figure 5.1-3. Landslides in the Project Area and Vicinity



Subsurface Conditions

The soil material beneath the project area is derived from the interaction of the river and the floodplain during high flow events, which deposit sediments consisting of sand, silt, and clay, as well as areas of peat (Anchor 2007; Anchor QEA 2011; GRI 2012; URS Corporation 2014a). Groundwater is found between 3 and 20 feet below the ground surface, so sediments have varying amounts of water content (Anchor QEA 2011, 2013; GRI 2012; URS Corporation 2014a). Geotechnical investigations indicate surface and near-surface sediments are soft or loose (URS Corporation 2014a). These conditions indicate the potential for some settlement under the weight of certain project features, such as stockpile pads, buildings, and rail loops. Field tests indicate the potential for large settlement of these underlying materials over a long period of time (URS Corporation 2014a).

Because saturated sandy soil conditions exist at the project area, liquefaction of soils could result from an earthquake. Geotechnical reports prepared for a previously proposed asphalt plant at the site identified the potential for post-earthquake liquefaction of soils to cause settlement of 7 to 16 inches (GeoEngineers 2007) and 12 to 16 inches (Shannon and Wilson 2008).

Landslides and Slope Stability

Landslides were not identified as a potential risk for the On-Site Alternative in local slope instability reports or on-site investigations (Figure 5.1-3) (Fiksdal 1989; Wegmann 2006; Anchor 2007; GRI 2011, 2012). The project area for the On-Site Alternative is flat; therefore, there is a low likelihood of landslides occurring. Much of the shoreline of the Columbia River has been armored with riprap along the length of the levee adjacent to the On-Site Alternative. The riprap protects the levee from erosion, while the levee itself disconnects the floodplain from the river.

Landslides have been identified on Mount Solo. Fiksdal (1989) identified two landslide areas on the eastern flanks of Mount Solo, as well as one on the north side and another on the south side (Figure 5.1-3). More detailed mapping by Wegmann (2006) identified multiple landslides around Mount Solo. Wegmann (2006) also determined whether the features were inactive or active. One of the active landslides is on the south side of Mount Solo, which could affect the project area. This landslide is formed by the exposed bedrock discussed in Section 5.1.4.1, *On-Site Alternative*. Landslides on Mount Solo could be caused by strong ground shaking from earthquakes or by substantial rainfall.

Seismicity

Pacific Northwest earthquakes are caused by one of four possible geologic events: movements between the tectonic plates on the coastal Cascadia Subduction Zone (CSZ), subduction of the Juan de Fuca plate sinking beneath the North American tectonic plate, shallow crustal movements in the North American tectonic plate, and movements related to volcanic activity.

No great earthquakes (magnitude 8.0 to 9.0[1] or higher) have occurred on the CSZ during the historical record but reconstructions from the geologic record show more than 10 great earthquakes have occurred in Oregon and Washington over the last 5,000 years (Cascadia Region Earthquake Workgroup 2013; URS Corporation 2014a). The interval in which these earthquakes reoccur is estimated at approximately 250 to 900 years with the last occurrence in 1700 (Atwater et al. 1994; Jacoby et al. 1997).

[1] The Richter scale is used to define the scale for earthquake magnitudes presented in this section.

Based on the historical record, plate movement due to the sinking of the Juan de Fuca plate under the North American plate is considered capable of causing earthquakes as large as magnitude 7.5 (URS Corporation 2014a). Earthquakes caused by this type of plate movement in Washington include the 1949 Olympia 7.1 magnitude, the 1965 Seattle 6.5 magnitude, and the 2001 Nisqually 6.8 magnitude. These earthquakes did not cause substantial damage in the Longview area (Noson et al. 1988; Washington Department of Natural Resources 2001; Washington State Seismic Safety Committee 2012; URS Corporation 2014a).

Shallow earthquakes in the earth's crust occur over large areas. Based on data gathered and historical records in the Pacific Northwest, these earthquakes can be greater than magnitude 6.0 and perhaps as high as magnitude 7.0 to 7.5 (URS Corporation 2014a). Shallow faults in southwestern Washington and northwestern Oregon have the potential to generate magnitude 6.0 and greater earthquakes (Wong et al. 2000; Lidke et al. 2003; Personius et al. 2003; URS Corporation 2014a).

Volcanic earthquakes occur beneath the Cascade volcanoes; Mount St. Helens is about 40 miles east of the project area. These earthquakes are associated with magma movement or volcanic faults within the Mount St. Helens seismic zone. The largest recorded earthquake beneath Cascade volcanoes was a magnitude 5.1 earthquake in 1981 (U.S. Geological Survey 2013).

Surface Fault Rupture

No shallow crustal faults are active or potentially active within the immediate vicinity of the project area (Lidke et al. 2003; Personius et al. 2003; Barnett et al. 2009; Czajkowski and Bowman 2014). The closest faults are the Portland Hills and Frontal Fault–Lacamas Lake Faults, about 40 miles to the southeast near Portland, Oregon (Wong et al. 2000; URS Corporation 2014a). The Mount St. Helens Seismic Zone is a fault line about 45 miles to the east and offshore faults are about 60 miles to the west.

Strong Ground Shaking

Large earthquakes between 1873 and 2014 potentially affecting the Longview area primarily took place in the Puget Sound area and Portland, Oregon. They range in magnitude from 5.0 to 7.1 (URS Corporation 2014a). Large earthquakes would cause severe ground shaking in the project area.

The USGS National Seismic Hazard Maps determine earthquake ground motions for different seismic thresholds used for seismic requirements in building codes. The maps display peak ground acceleration, the measure of the ground's acceleration from no motion at all to a peak motion during ground shaking. This acceleration causes shaking and stress on structures. A peak ground acceleration in the range of 0.34 to 0.65 gravity (g) is regarded as severe shaking and could cause moderate to heavy damage to buildings or structures, depending on the duration of the event, the types of underlying materials, and the structural integrity of the affected buildings or structures (Petersen et al. 2014). The USGS map shows a peak ground acceleration in the study area between 0.4 to 0.5 g, which has a 2% chance of being exceeded in 50 years (Petersen et al. 2014).

Ground shaking is also stronger in areas of soft soils or loose deposits such as sand and silt. The Site Class Map of Cowlitz County, Washington, shows the project area as site class E, which has the softest soil conditions and highest level of potential ground shaking (Palmer et al. 2004).

Cascadia Region Earthquake Workgroup (2013) notes underwater landslides, which could disrupt the Columbia River navigation channel and adjacent industrial and commercial berthing areas, also pose a ground shaking and liquefaction hazard to the area.

Secondary Seismic Hazards: Liquefaction and Subsidence

Liquefaction occurs when stress such as ground shaking causes saturated or partially saturated soil to lose its strength and act like a fluid. The project area has potential for liquefaction during ground shaking. The Liquefaction Susceptibility Map of Cowlitz County, Washington, shows the area as having high liquefaction potential (Palmer et al. 2004).

The geologic record provides evidence of liquefaction potential along the Columbia River. Previous investigations at the site for a proposed asphalt plant resulted in similar estimates for settlement from liquefaction ranging from 7 to 16 inches for a CSZ earthquake ranging from magnitudes 7.4 to 8.3, though this varies with location.

Volcanic Hazards

The main volcanic hazard at Longview is from airborne fragments, ash fall, and lahars (volcanic mudflows) reaching, and continuing down, the Columbia River. Active volcanoes within the Cascade Range lie to the east of Longview, with the closest active volcano being Mount St. Helens about 40 miles to the east. The project area does not lie within any of the three Cowlitz County-designated volcanic flowage hazard zones. USGS estimates the annual chance of ash fall greater than 4 inches at Longview to be between 0.01% and 0.02% or between 1 in 10,000 to 1 in 5,000 (Wolfe and Pierson 1995).

Lahars originating from the south flank of Mount Rainier in the upper Cowlitz River are unlikely to reach the lower Cowlitz River (Cakir and Walsh 2012). Lahars have been documented upstream along the Sandy River draining from Mount Hood in Oregon (Pierson et al. 2009) at approximately 55 miles upstream of Longview. Lahars from Mount Adams could reach the Columbia River via the White Salmon River; its confluence is more than 100 river miles upstream of Longview. The Longview area is also not within any of the three Cowlitz County-designated volcanic flowage hazard zones. Although the Cowlitz River adjacent to Longview is designated as a Cowlitz County-designated volcanic flowage hazard zone 3 (zone 3 areas typically require a an evacuation and emergency management plan).

Mine Hazard Areas

Mine hazard areas in Cowlitz County are mainly associated with historical coal mining and areas affected by mine workings such as adits, tunnels, drifts, or airshafts. There is no bedrock with coal along the Columbia River in the Longview area.

Tsunamis

Washington and Oregon tsunamis could result from CSZ earthquakes along their coastline or similar major earthquakes in areas such as southern Alaska, Japan, or Indonesia. Tsunami hazard and evacuation maps for Washington and Oregon only extend up the Columbia River to a point just east of Astoria, Oregon (river mile 15, approximately 50 miles downstream of the project area)(Walsh et al. 2000; Washington Department of Natural Resources 2010; Oregon Department of Geology and Mineral Industries 2012). Modeling calculations found an 18-foot-high tsunami at the Columbia River mouth would decrease to less than 8 inches at Longview (Yeh et al. 2012).

Sea-Level Rise

Sea-level rise in the Pacific Northwest is expected to be as little as 5 inches or less to more than 4 feet by the end of the century. The project area is approximately 60 miles inland from the mouth of the Columbia River, and sea-level rise at the project area is expected to be minimal. Further, the project area is behind Columbia River levees of approximately 36 feet above sea level, and since this is higher than the potential sea-level rise, there would not be any impacts on soils on the project area or an increased risk of erosion.

Soils in the Project Area and Vicinity

Cowlitz County soils have been mapped by NRCS (2013). These soil units and some of their characteristics are shown in Table 5.1-2. Excluding water, five soil units are mapped at the project area (Figure 5.1-4). All of these soil units reflect the alluvial (river deposit) origin of the soil material and are relatively fine-grained.

Table 5.1-2. Soils and Soil Properties in the On-Site Alternative Project Area

Map Unit Number[a]	Soil Map Unit Name	Drainage Class	K Factor[b]	Erosion Hazard	Corrosion of Concrete[c]	Corrosion of Uncoated Steel[d]	Linear Extensibility (Class)
5	Arents, 0 to 5% slopes	Moderately well drained	0.28	Slight	Moderate	Moderate	1.5% (Low)
17	Caples silty clay loam, 0 to 3% slopes	Somewhat poorly drained	0.43	Slight	Moderate	High	7.0% (High)
127	Maytown silt loam, 0 to 3% slopes	Moderately well drained	0.49	Slight	Moderate	High	3.6% (Moderate)
160	Pilchuck loamy fine sand, 0 to 8% slope	Not defined	0.20	Slight	Moderate	Low	1.5% (Low)
199	Snohomish silty clay loam, 0 to 1% slopes	Poorly drained	0.37	Slight	Moderate	High	4.5% (Moderate)
263	Water	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

[a] Soil Map Units are shown in Figure 5.1-4.

[b] Higher K factor values indicate greater potential for erosion: K factor values below 0.13 have low erosion potential; values 0.13 to 0.26 have medium erosion potential; values greater than 0.26 have high erosion potential.

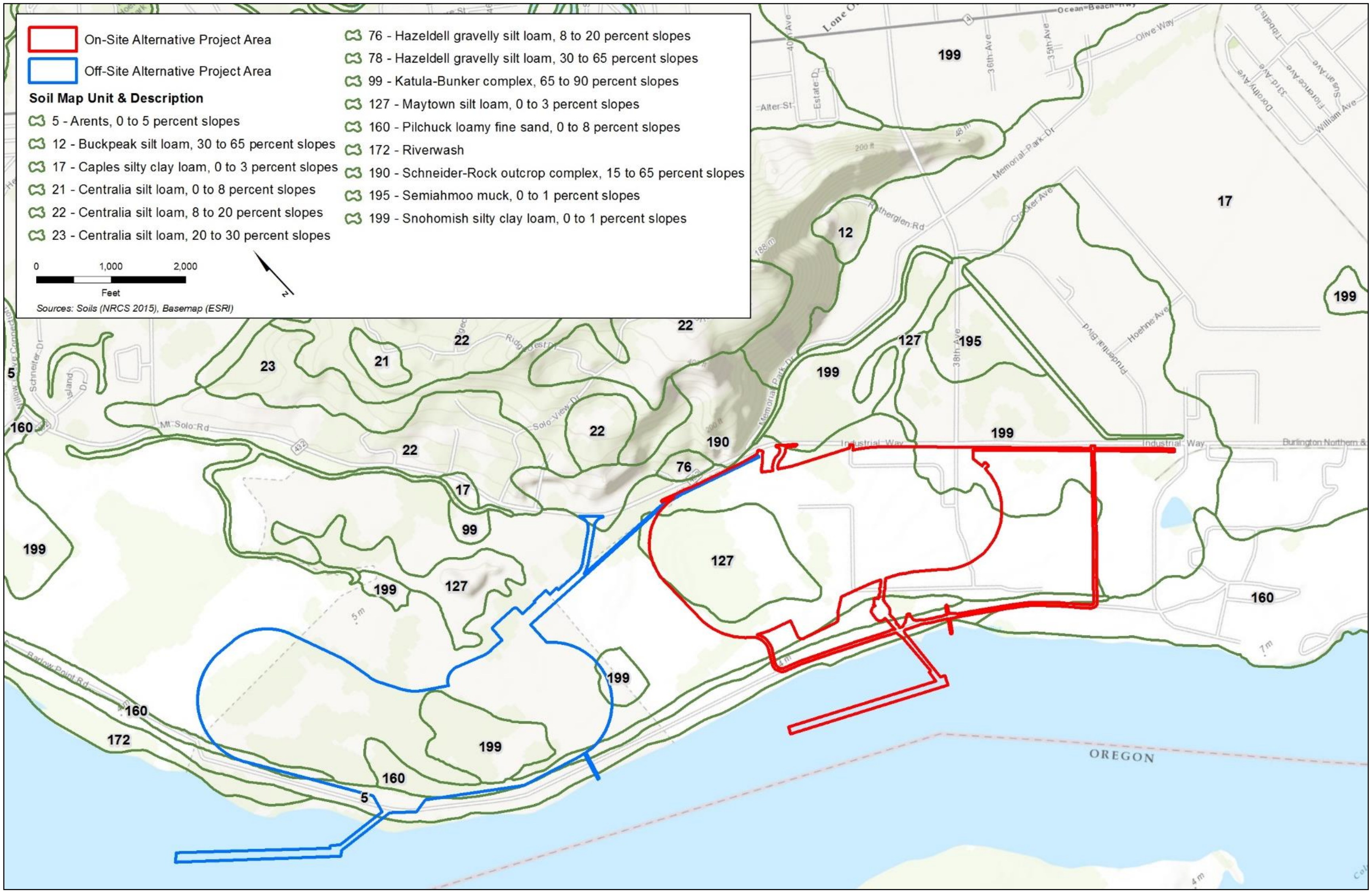
[c] The potential for concrete corrosion increases decreasing water and soil acidity and increases in sodium, magnesium sulfate, and sodium chloride.

[d] The potential for corrosion of uncoated steel increases with soil water saturation, greater water acidity and conductivity.

Source: Natural Resources Conservation Service 2013.

N/A = not applicable

Figure 5.1-4. Soil Types in the Project Area and Vicinity



The erosion hazard is considered slight for all of the soils in the study area. The Caples silty clay loam (Map Unit Number 17), the Maytown silt loam (Map Unit 127), and Snohomish silty clay loam (Map Unit Number 199) have a higher erosion hazard under bare soil conditions. These soils have a low susceptibility to wind erosion.

The site soils are all moderate regarding their potential for corrosion of concrete. Several engineering measures address concrete and steel corrosion, such as improving drainage and replacing native soil with fill (Washington State Department of Transportation 2014).

A soil's linear extensibility is the measure of its potential to expand during wetting and to contract during drying. The more a soil expands the more potential it has to affect overlying materials such as structure foundations. The soil expansion classes for the project area range from low (Arents, Pilchuck loamy fine sand), to moderate (Maytown silt loam, Snohomish silty clay loam), to high (Caples silty clay loam). The values in Table 5.1-2 are provided as a percent expansion and a descriptive classification (class).

The above discussion relates to the naturally occurring soils at the project area. However, the project area has been an industrial site since the 1940s and has had various amounts of surface disturbance and fill material (sand, silt, mixed silt and sand, large gravel, and crushed rock [Anchor QEA 2011; GRI 2011, 2012]) placement. Due to the industrial use, site-specific surface soil materials could vary from NRCS mapping. Data reports for the project area indicate varying areas of fill materials, particularly under existing structures.

5.1.4.2 Off-Site Alternative

The following sections describe the affected environment related to the geology and soils in the project area for the Off-Site Alternative and the surrounding area.

Local and Site Geology

The project area for the Off-Site Alternative is located about 0.3 mile west (downstream) of the project area for the On-Site Alternative. It is about 5 to 15 feet above sea level; it lies above river and floodplain deposits and the surface is level. The adjacent Columbia River navigation channel is approximately 32 to 46 feet deep at low tide and from about 10 to 42 feet deep at low tide at the location of the proposed docks (Dock A and Dock B) according to the National Oceanic and Atmospheric Administration Chart 18524. Levees were constructed along the riverside of the project area (Figure 5.1-2) in approximately 1920 (Anchor QEA 2011). No unique physical geologic features are present at the project area.

The local geology of the project area is the same as described for the project area for the On-Site Alternative (URS Corporation 2014b).

Although no detailed subsurface geotechnical information is available for the project area, the overall conditions are expected to be very similar to the project area for the On-Site Alternative, because of the similar landscape position, proximity, and similarity of deposits along this portion of the Columbia River (Peterson et al. 2013).

Subsurface Conditions

Although geotechnical data are not available for the project area, Peterson et al. (2013) presents directly connected cross-sections from the immediate area. The similarity in sediment deposits shows the geotechnical characteristics at the project area for the On-Site Alternative are generally the same for the Off-Site Alternative project area.

Landslides and Slope Stability

No landslides are identified for the project area in local slope instability reports (Figure 5.1-3) (Fiksdal 1989; Wegmann 2006). The project area is also flat and, therefore, has a low likelihood of landslides. Much of the shoreline has been armored with large riprap and angular rock along the length of the levee adjacent to the Off-Site Alternative location along the Columbia River, thereby disconnecting the river from its floodplain and protecting the levee system from erosion.

There are two active landslides on Mount Solo relevant to the project area (Figure 5.1-3). The larger (approximately 16-acre) active landslide on the south slope of Mount Solo is approximately 0.5 mile from the northeast corner of the project area. The smaller (approximately 0.56-acre) landslide at the western portion of the Mount Solo area is more than 0.5 mile north of the project area, is facing to the north, and has a low bedrock ridge to the south which isolates it from the project area (Figure 5.1-3) (Wegmann 2006).

Seismicity

The seismicity discussion provided for the On-Site Alternative applies to the Off-Site Alternative project area.

Volcanic Hazards

The discussion of volcanic hazards provided for the On-Site Alternative applies to the Off-Site Alternative project area.

Tsunamis

The discussion of tsunamis provided for the On-Site Alternative applies to the Off-Site Alternative project area.

Sea-Level Rise

The discussion of sea-level rise provided for the On-Site Alternative applies to the Off-Site project area.

Soils

The discussion of soils for the On-Site Alternative applies to the Off-Site Alternative project area except Soil Number 127, Maytown silt loam (Figure 5.1-4, Table 5.1-2), which is not at the Off-Site Alternative project area. Moreover, the naturally occurring soils mapped are representative of the affected environment at the project area.

5.1.5 Impacts

This section describes the potential direct and indirect impacts related to geology and soils resulting from construction and operation of the proposed export terminal.

5.1.5.1 On-Site Alternative

This section describes the potential impacts occurring in the study area[2] as a result of construction and operation of the proposed export terminal.

Construction activities could affect geology and soils directly through ground disturbance associated with construction of the export terminal for the shipment of coal and preloading of the coal stockpile areas. Operational activities could affect geology and soils indirectly through exposure of people and structures to potential effects from catastrophic events

Construction—Direct Impacts

Construction-related activities associated with the On-Site Alternative could result in direct impacts as described below. As explained in Chapter 3, *Alternatives,* construction-related activities include demolishing existing structures and preparing the site, constructing the rail loop and dock, and constructing supporting infrastructure (i.e., conveyors and transfer towers).

Land, Physical Features, and Soil Erosion

Construction of the On-Site Alternative would not result in the enlargement of land area by placing fill in the Columbia River or by depositing sediments in the Columbia River. There are no unique physical features at the project area affected by the On-Site Alternative. Although steep slopes occur along drainage ditches and the Columbia River banks, there are no indications of instability and project activities are not expected to cause instability at these locations.

Construction at the On-Site Alternative location would involve ground-disturbing activities such as grading, railroad construction, excavating for foundations, and road construction affecting about 190 acres of land. Approximately 2.1 million cubic yards of material would be imported for compressing soils on site, as well as about 130,000 cubic yards of ballast rock for rail-related structures and infrastructure. Approximately 2.5 million cubic yards of material would be moved around the project area during the compression of on-site soils.

As discussed in Section 5.1.4.1, *On-Site Alternative*, and shown in Table 5.1-2, although the soils in the project vicinity have a moderate to high potential for erosion, the soils in the project area have a slight erosion hazard mainly due to the project area's flat, low gradient. Bare soil could be exposed for varying periods of time due to construction activities occurring over several years. This could lead to potential soil erosion due to rainfall or wind. Soil erosion would have the potential for off-site transport of eroded soil materials to waterways such as the Columbia River and adjacent ditches. However, construction best management practices (e.g., seeding temporarily disturbed areas, installing and monitoring silt fencing, and adhering to the stormwater pollution prevention plan). Imported preload and rail ballast materials would be obtained commercially from an appropriate source. Wind erosion potential would be limited

[2] Acreages presented in the impacts analysis were calculated using geographic information system (GIS) technology, thus, specific acreage of impacts are an estimate of area based on the best available information.

due to seasonal precipitation and dust suppression during construction, but could occur during summer dry periods. Dust from coal stockpiles is addressed in Chapter 6, Section 6.6, *Air Quality*. When build-out is complete, the project area would be approximately 90% impervious surfaces, which would reduce soil erosion potential to near zero.

Dredging would occur at Docks 2 and 3. This activity is discussed in Sections 5.2, *Surface Water and Floodplains,* and 5.5, *Water Quality*.

Project Structures

As discussed in Section 5.1.4.1, *On-Site Alternative*, and shown in Table 5.1-2, the on-site soils have moderate potential to corrode concrete, low to high potential to corrode steel, and have an expansion-contraction (wet-dry) class of low to high. Impacts related to corrosion of project-related structures and infrastructure would be avoided through standard engineering and construction methods. Washington State Department of Transportation (2014) uses a variety of standard engineering measures to address concrete and steel corrosion such as improving drainage and replacing native soil with fill. Such standard engineering measures would be employed by the Applicant to ensure potential soil related corrosion would not occur.

The sediments beneath the project area are relatively fine-grained and water-saturated, and the water table is near the ground surface. These characteristics make the sediments vulnerable to compaction from the weight of overlying materials and structures. This vulnerability is mainly a concern for the coal stockpile areas on the project area due to the coal’s weight. Thus, preloading and installing wick drains is required to expel the groundwater and consolidate soils beneath the stockpile areas prior to operations. Compaction would be less of a concern for other project components because they involve much less weight.

Compaction and settlement of underlying sediments in the coal stockpile areas are addressed in the project design through preloading. Preloading involves importing material to compact the underlying soil to improve its load-bearing capacity. Approximately 2.1 million cubic yards of material would be imported into the coal stockpile areas in stages over a period of up to 7 years. Preloading would provide soil compaction to avoid potential impacts associated with soil settlement during operations.

Construction—Indirect Impacts

Construction of the On-Site Alternative would not result in indirect impacts on geology and soils because construction impacts would be immediate and would be limited to the project area. Therefore, no construction impacts would occur later in time or farther removed in distance from the direct impacts on the project area.

Operations—Direct Impacts

The On-Site Alternative would result in the following direct impacts.

Operation of the terminal could expose people or structures to potential effects involving catastrophic events such as; rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure (liquefaction), landslides, and tsunamis. Thus, potential effects from these types of catastrophic events were evaluated.

Earthquake Faults

There are no earthquake faults in the study area reaching the ground surface. Therefore, no ground surface ruptures could directly damage structures or buildings in the study area.

Ground Shaking

The project area and surrounding area could be subject to strong ground shaking from earthquakes. The USGS National Seismic Hazard Maps estimate earthquake probability in the area with a peak ground acceleration of greater than 0.4 g at a 2% probability of occurrence (Petersen et al. 2014). This amount of shaking could directly damage proposed structures and buildings. As per the Cowlitz County Critical Areas Protection Ordinance (Cowlitz County Code [CCC] 19.15), construction of the terminal would be required to comply with International Building Code 16.05 and Cowlitz County Grading Ordinance 16.35, as applicable. Additionally, a geotechnical report would be prepared as part of the On-Site Alternative and would inform project design and construction techniques, which would likely reduce potential impacts associated with ground shaking.

Seismic-Related Ground Failure (Liquefaction)

The study area could be subject to liquefaction during strong ground shaking. Palmer et al. (2004) characterizes the area as having high liquefaction susceptibility. An investigation of the area was conducted for a previously proposed asphalt plant, which indicated settlement after liquefaction would vary with earthquake location and earthquake magnitude. The investigations concluded ground settling due to post-liquefaction settlement could damage the proposed structures and buildings. The On-Site Alternative would comply with the adopted International Building Code (per CCC 16.05 and 16.35 Grading Ordinance). Preloading the stockpile area would expel groundwater and consolidate soils in the immediate vicinity of the coal stockpile areas, which would reduce the susceptibility of the soils to liquefaction. This would also likely reduce the potential for damage to proposed structures in the immediate vicinity of the preloading area. Preparation of a geotechnical report would identify the specific soil conditions pre- and post-project construction, and would inform project design and construction techniques to further reduce potential impacts based on the potential susceptibility of liquefaction.

Landslides

There are no existing landslides in the study area. Strong ground shaking associated with earthquakes would have minimal potential to cause new landslides in the study area, because the area is level and there is only about 40 feet of elevation difference between the site surface and the adjacent Columbia River bottom.

The project area is near the active deep-seated landslide on the south side of Mount Solo, but it is approximately 250 feet from the edge of the estimated greatest extent of the landslide, more than the 50 feet required by the Cowlitz County Critical Areas Ordinance (CCC 19.15) for landslide hazards. However, as with all landslides, periods of prolonged and intense rainfall (including multiyear periods) or earthquake-caused ground shaking could trigger this landslide. However, because the project area is approximately 200 feet beyond the minimum distance required by the Cowlitz County Critical Areas Ordinance (CCC 19.15) and it is physically isolated from the landslide, the On-Site Alternative would not increase the risk of a landslide, nor would it be expected, if a landslide were to occur, it would affect the proposed export terminal.

Tsunamis

Large earthquakes in the Pacific Ocean or on the CSZ could cause a tsunami, which could affect the coastal zone of Washington and Oregon. Large tsunamis have been detected as far up the Columbia River as Portland, Oregon. Modeling calculations found an 18-foot-high tsunami at the Columbia River mouth decreased to less than 8 inches at Longview (Yeh et al. 2012). Tsunami levels at the project area would be similar and would not affect project-area structures or operations, including ships at the docks.

Operations—Indirect Impacts

Operation of the On-Site Alternative would not result in any indirect impacts on geology or soils because operations would not result in any changes to soils or geology occurring later in time or beyond the direct impacts study area.

5.1.5.1 Off-Site Alternative

The site plan and design (size of project area, project elements, and construction activities) for the Off-Site Alternative are very similar to the On-Site Alternative. Moreover, the local geology, landscape position, subsurface conditions, and soils are virtually identical between the two areas (Peterson et al. 2013). Therefore, the construction-related direct impacts of the Off-Site Alternative would be the same as, or similar to, those described for the On-Site Alternative.

Construction—Direct Impacts

Construction of the terminal would result in impacts similar to those described for the On-Site Alternative. The following discussion is focused on the differences in direct impacts potentially resulting from construction of the Off-Site Alternative.

Soil Erosion

Erosion hazards under the Off-Site Alternative would be the same as described for the On-Site Alternative. When build-out is complete, the Off-Site Alternative project area would be about 90% impervious surfaces, which would reduce soil erosion potential to near zero. Dredging would occur at Docks A and B, which is discussed in Sections 5.2, *Surface Water and Floodplains*, and 5.5, *Water Quality.*

Project Structures

The potential impacts on the project structures from soil materials would be the same as described for the On-Site Alternative.

Construction—Indirect Impacts

The Off-Site Alternative would not result in indirect impacts on geology and soils because construction impacts would be immediate and would not occur later in time or farther than the direct impacts study area.

Operations—Direct Impacts

Operation of the proposed export terminal at the Off-Site Alternative location would result in the following direct impact.

Catastrophic Events

Operation of the terminal could expose people or structures to potential effects involving catastrophic events such as rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure (liquefaction), landslides, and tsunamis. The impacts would be the same or similar to those described for the On-Site Alternative. The project area has no surface faults that would affect the site or its structures. The project area would experience the same ground-shaking-related ground failure (including the liquefaction potential), landslides, and tsunamis as the On-Site Alternative project area. Although no site-specific data were collected nor any analyses conducted for the Off-Site Alternative project area, the area's general characteristics are expected to be similar to the On-Site Alternative project area, because the local geology, landscape position, subsurface conditions, and soils are virtually identical between the two areas (Section 5.1.4.1, *On-Site Alternative*; Peterson et al. 2013).

The Off-Site Alternative would comply with the adopted International Building Code or International Residential Code (CCC 19.15).

Operations—Indirect Impacts

No indirect impacts have been identified for geology or soils related to operation of the terminal at the Off-Site Alternative location.

5.1.5.2 No-Action Alternative

Under the No-Action Alternative, the Corps would not issue a Department of the Army permit authorizing construction and operation of the proposed export terminal. As a result, impacts resulting from constructing and operating the terminal would not occur. In addition, not constructing the terminal would likely lead to expansion of the adjacent bulk product business onto the export terminal project area.

The potential impacts on geology and soils could occur under the No-Action Alternative similar to what is described for the On-Site Alternative, but the magnitude of the impact would depend on the nature and extent of the future expansion.

5.1.6 Required Permits

The following permits related to geology and soils would be required for the proposed export terminal.

5.1.6.1 On-Site Alternative

The On-Site Alternative would require the following permits for geology and soils.

- **Fill and Grade Permits/Building Permits—Cowlitz County**. Fill and grade permits and building permits would be required from Cowlitz County to ensure final design and construction follow the County and engineering requirements.

- **Critical Areas Permit—Cowlitz County**. The On-Site Alternative would require a Critical Areas Permit to address compliance with Cowlitz County's Critical Areas Ordinance related to the presence and protection of Critical Aquifer Recharge Areas located on site.
- **Construction Stormwater General Permit—Washington State Department of Ecology.** A Construction Stormwater General Permit would be required from the Washington State Department of Ecology to address erosion control and water quality during construction.
- **Industrial Stormwater General Permit—Washington State Department of Ecology.** An industrial Stormwater General Permit would be required from the Washington State Department of Ecology to address erosion control and water quality during operations. The permit and stormwater pollution prevention plan control adverse impacts through the application of best management practices. Best management practices are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and managerial practices, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts on waters of Washington State. The types of best management practices are source control, treatment, and flow control.

5.1.6.2 Off-Site Alternative

The Off-Site Alternative would require the following permits related to geology and soils.

- **Building Permit—City of Longview.** A building permit would be required from the City of Longview to ensure final design and construction follow the City of Longview engineering requirements.
- **Critical Areas Permit—Cowlitz County and City of Longview**. A Critical Areas Permit may be required to address compliance with the County and City's Critical Areas Ordinances should critical aquifer recharge areas be located on or adjacent to the Off-Site Alternative project area.
- **Construction Stormwater General Permit and Industrial Stormwater General Permit—** Washington State Department of Ecology. Permits would be required, for the same reasons described for the On-Site Alternative.